

1

Introduction to Dietary Reference Intakes

Dietary Reference Intakes (DRIs) comprise a set of reference values for specific nutrients, each category of which has special uses. The development of DRIs expands on the periodic reports called *Recommended Dietary Allowances*, published from 1941 to 1989 by the National Academy of Sciences, and *Recommended Nutrient Intakes*, published by the Canadian government. This comprehensive effort is being undertaken by the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes of the Food and Nutrition Board, Institute of Medicine, the National Academies, in collaboration with Health Canada. See Appendix B for a description of the overall process, its origins, and other relevant issues that developed as a result of this new process.

WHAT ARE DIETARY REFERENCE INTAKES?

The reference values, collectively called the Dietary Reference Intakes (DRIs), include the Estimated Average Requirement (EAR), Recommended Dietary Allowance (RDA), Adequate Intake (AI), and Tolerable Upper Intake Level (UL) (Box 1-1). Establishment of these reference values requires that a criterion of nutritional adequacy be carefully chosen for each nutrient, and that the population for whom these values apply be carefully defined.

A requirement is defined as the lowest continuing intake level of a nutrient that, for a specific indicator of adequacy, will maintain a defined level of nutriture in an individual. The chosen criterion or indicator of nutritional adequacy upon which EARs and AIs are based is identified for each nutrient. The criterion may differ for individuals at different life stages. Particular attention is given throughout this report to the choice

BOX 1-1
Dietary Reference Intakes

Recommended Dietary Allowance (RDA): *the average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group.*

Adequate Intake (AI): *the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate—used when an RDA cannot be determined.*

Tolerable Upper Intake Level (UL): *the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.*

Estimated Average Requirement (EAR): *the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group.^a*

^a In the case of energy, an Estimated Energy Requirement (EER) is provided. The EER is the average dietary energy intake that is predicted to maintain energy balance in a healthy adult of a defined age, gender, weight, height, and level of physical activity consistent with good health. In children and pregnant and lactating women, the EER is taken to include the needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health.

and justification of the criterion used to establish requirement values and the intake levels beyond which the potential for increased risk of adverse effects may occur.

CATEGORIES OF DIETARY REFERENCE INTAKES

Estimated Average Requirement¹

The *Estimated Average Requirement* (EAR) is the daily intake value that is estimated to meet the requirement, as defined by the specified indicator

¹The definition of EAR implies a median as opposed to a mean, or average. The median and average would be the same if the distribution of requirements followed a symmetrical distribution and would diverge if a distribution were skewed.

or criterion of adequacy, in half of the apparently healthy individuals in a life stage or gender group (see Figure 1-1). A normal or symmetrical distribution (median and mean are similar) is usually assumed for setting the EAR. At an intake level equal to the EAR, half of a specified group would not have their nutritional needs met. This is equivalent to saying that randomly chosen individuals from the population would have a 50:50 chance of having their requirement met at this intake level. This use follows the precedent set by others who have used the term “Estimated Average Requirement” for reference values similarly derived but meant to be applied to population intakes (COMA, 1991).

The EAR’s usefulness as a predictor of an individual’s requirement depends on the appropriateness of the choice of the nutritional status indicator or criterion and the type and amount of data available. The general method used to set the EAR is the same for all nutrients. The specific approaches, which are provided in Chapters 5 through 10, differ since each nutrient has its own indicator(s) of adequacy, and different amounts and types of data are available for each.

The EAR serves three major functions: as the basis for the Recommended Dietary Allowance (RDA), as the primary reference point for

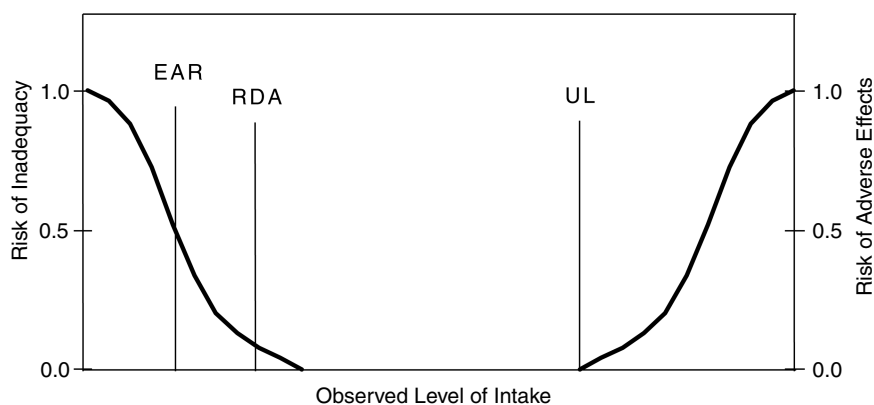


FIGURE 1-1 Dietary Reference Intakes. This figure shows that the Estimated Average Requirement (EAR) is the intake at which the risk of inadequacy is estimated to be 0.5 (50 percent) to an individual. The Recommended Dietary Allowance (RDA) is the intake at which the risk of inadequacy would be very small—only 0.02 to 0.03 (2 to 3 percent). At intakes between the RDA and the Tolerable Upper Intake Level (UL), the risk of inadequacy and of excess are both estimated to be close to 0.0. At intakes above the UL, the potential risk of adverse effects may increase.

assessing the adequacy of estimated nutrient intakes of groups (IOM, 2000a), and, together with estimates of the variance of intake, in planning for the intake of groups (see Chapter 13).

Recommended Dietary Allowance

The *Recommended Dietary Allowance* (RDA) is an estimate of the minimum daily average dietary intake level that meets the nutrient requirements of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group (see Figure 1-1). The RDA is intended to be used as a goal for daily intake by individuals as this value estimates an intake level that has a high probability of meeting the requirement of a randomly chosen individual (about 97.5 percent). The process for setting the RDA is described below; it depends on being able to set an EAR and estimating the variance of the requirement itself. Note that if an EAR cannot be set due to limitations of the data available, no RDA will be set.

This approach differs somewhat from that used by the World Health Organization, Food and Agriculture Organization, and International Atomic Energy Agency (WHO/FAO/IAEA) Expert Consultation on *Trace Elements in Human Nutrition and Health* (WHO, 1996). That publication uses the term *basal requirement* to indicate the level of intake needed to prevent pathologically relevant and clinically detectable signs of a dietary inadequacy. The term *normative requirement* indicates the level of intake sufficient to maintain a desirable body store, or reserve. In developing an RDA (and Adequate Intake [AI], see below), emphasis is placed instead on the reasons underlying the choice of the criterion of nutritional adequacy used to establish the requirement. It is not designated as basal or normative.

Method for Setting the RDA When Nutrient Requirements Are Normally Distributed

When the distribution of a requirement among individuals in a group can be assumed to be approximately normal (or symmetrical), and a standard deviation (SD) of requirement ($SD_{\text{requirement}}$) can be determined, the EAR can be used to set the RDA as follows:

$$RDA = EAR + 2 \times SD_{\text{requirement}}$$

If data about variability in requirements are insufficient to calculate an $SD_{\text{requirement}}$ for that specific nutrient in that population group, but normality or symmetry can be assumed, then a coefficient of variation (CV) of 10 percent will be assumed and the calculation becomes:

$$\text{RDA} = \text{EAR} + 2 (0.1 \times \text{EAR}) = 1.2 \times \text{EAR}.$$

The assumption of a 10 percent CV is based on extensive data on the variation in basal metabolic rate (FAO/WHO/UNA, 1985; Garby and Lammert, 1984) and the CV of 12.5 percent estimated for the protein requirements in adults (FAO/WHO/UNA, 1985). If there is evidence of greater variation, a larger CV will be used. In all cases, the method used to derive the RDA from the EAR is stated.

Since it is derived from the EAR, the RDA's usefulness as a goal depends on the choice of nutritional status indicator or criterion and the type and amount of data available. Its applicability also depends on the accuracy of the form of the requirement distribution and the estimate of the variance of requirements for the nutrient in the population subgroup for which it is developed.

For many of the macronutrients, there are few direct data on the requirements of children. In this case, EARs and RDAs for children are based on extrapolations from adult values. The methods for extrapolation are described in Chapter 2.

Method for Setting the RDA When Nutrient Requirements Are Not Normally Distributed

If the requirement of a nutrient is not normally distributed but can be transformed to normality, its EAR and RDA can be estimated by transforming the data, calculating the 50th (for the EAR) and the 97.5th percentiles (for the RDA), and transforming these percentiles back into the original units. In this case, the difference between the EAR and RDA cannot be used to obtain an estimate of the variance in the requirement (the SD or CV) since skewing is present.

Where factorial modeling is used to estimate the distribution of a requirement from the distributions of the individual components of the requirement (maintenance and growth), as was done in the case of protein and amino acid recommendations for children, it is necessary to add (termed *convolve*) the individual distributions. Estimating the convolution of two distributions in general is very difficult. However, this is easy to do with normal distributions since the average requirement is simply the sum of the averages of the individual component distributions, and an SD of the combined distribution can be estimated by standard statistical techniques. The 97.5th percentile can then be estimated. (For a discussion of the method, see Appendix B.)

Adequate Intake

If sufficient scientific evidence is not available to calculate an EAR, a reference intake called an *Adequate Intake* (AI) is provided instead of an RDA. The AI is a value based on experimentally determined approximations or estimates of observed median nutrient intakes by a group (or groups) of healthy people. In the judgment of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, the AI is expected to meet or exceed the amount needed to maintain a defined nutritional state or criterion of adequacy in essentially all members of a specific, apparently healthy, population. Examples of defined nutritional states include normal growth, maintenance of normal circulating nutrient values, or other aspects of nutritional well-being or general health.

For young infants for whom human milk is the recommended sole source of food for most nutrients for the first 4 to 6 months of life, the AI is based on the daily mean nutrient intake of human milk in healthy, full-term infants who are exclusively fed human milk. The goal may be different for infants consuming infant formula for which the bioavailability of a nutrient may be different from that in human milk. For adults, the AI may be based on data from a single experiment, on estimated dietary intakes in apparently healthy population groups, or on a review of data from different approaches that, when considered alone, do not permit a reasonably confident estimate of an EAR.

Comparison of the Recommended Dietary Allowance and the Adequate Intake

There is much less certainty about an AI value than about an RDA value. Because AIs depend on a greater degree of judgment than is applied in estimating an EAR and subsequently an RDA, an AI may deviate significantly from, and may be numerically higher than, an RDA. For this reason, AIs must be used with greater care than is the case for RDAs. Also, an RDA is usually calculated from an EAR by using a formula that takes into account the expected variation in the requirement for the nutrient.

Both the AI and RDA are to be used as a goal for individual intake. In general, the values are intended to cover the needs of nearly all apparently healthy individuals in a life stage group. (For infants, the AI is the mean intake when infants in the age group are consuming human milk. Larger infants may have greater needs, which they meet by consuming more milk.) The AI for a nutrient is expected to exceed the RDA for that nutrient, and thus it should cover the needs of more than 97 to 98 percent of individuals. The degree to which the AI exceeds the RDA is likely to differ among nutrients and population groups. As with RDAs, AIs for children and ado-

lescents may be extrapolated from adult values if no other usable data are available.

For people who have diseases that increase specific nutrient requirements or who have other special health needs, the RDA and AI each may serve as the basis for adjusting individual recommendations. Qualified health professionals should adapt the recommended intake to cover higher or lower needs.

Tolerable Upper Intake Level

The *Tolerable Upper Intake Level* (UL) is the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects for almost all individuals in the specified life stage group (see Figure 1-1). As intake increases above the UL, there is the potential for an increased risk of adverse effects. The term *tolerable* was chosen to avoid implying a possible beneficial effect. Instead, the term is intended to connote a level of intake that can, with high probability, be tolerated biologically. The UL is not intended to be a recommended level of intake, as there is no established benefit for healthy individuals if they consume a nutrient in amounts exceeding the recommended intake (the RDA or AI).

The UL is based on an evaluation conducted by using the methodology for risk assessment of nutrients (see Chapter 4). The need for setting ULs has arisen as a result of the increased fortification of foods with nutrients and the use of dietary supplements by more people and in larger doses. The UL applies to chronic daily use and is usually based on the total intake of a nutrient from food, water, and supplements if adverse effects have been associated with total intake. However, if adverse effects have been associated with intake from supplements or food fortificants only, the UL is based on nutrient intake from one or both of those sources only, rather than on total intake. As in the case of applying AIs, professionals should avoid very rigid application of ULs and first assess the characteristics of the individual or group of concern (e.g., source of nutrient, physiological state of the individual, length of sustained high intakes, etc.).

For some nutrients, data may not be sufficient for developing a UL. This indicates the need for caution in consuming amounts greater than the recommended intake; it does not mean that high intake poses no potential risk of adverse effects.

The safety of routine, long-term intake above the UL is not well documented. Although members of the general population should be advised not to routinely exceed the UL, intake above the UL may be appropriate for investigation within well-controlled clinical trials. Clinical trials of doses above the UL should not be discouraged as long as subjects participating in these trials have signed informed consent documents regarding pos-

sible toxicity and as long as these trials employ appropriate, safe monitoring of trial subjects.

DETERMINATION OF ADEQUACY

Adequacy

In the derivation of Estimated Average Requirements (EARs) or Adequate Intakes (AIs), close attention has been paid to the determination of the most appropriate indicators of adequacy. A key question is, Adequate for what? In many cases, a continuum of benefits may be ascribed to various levels of intake of the same nutrient. One criterion may be deemed the most appropriate to determine the risk that an individual will become deficient in the nutrient, whereas another may relate to reducing the risk of a chronic degenerative disease, such as certain neurodegenerative diseases, cardiovascular disease, cancer, diabetes mellitus, or age-related macular degeneration.

Each EAR and AI is described in terms of the selected criterion or indicator of adequacy. The potential role of the macronutrients in the reduction of disease risk was considered in developing the EARs. With the acquisition of additional data relating intake more directly to chronic disease or disability, more sensitive and reliable indicators or criteria may be validated and thus the criterion for setting the EAR may change.

Role in Health

Unlike other nutrients, energy-yielding macronutrients can be used somewhat interchangeably (up to a point) to meet energy requirements of an individual. In this report, EARs or AIs have been provided for specific macronutrients or components of these classes of macronutrients where the data were adequate to establish a causal relationship between intake and a specific function or chosen criterion of adequacy. However, for the general classes of nutrients and some of their subunits, this was not always possible; the data do not support a specific number, but rather trends between intake and chronic disease identify a range. Given that energy needs vary with individuals, a specific number was not deemed appropriate to serve as the basis for developing diets that would be considered to decrease risk of disease, including chronic diseases, to the fullest extent possible. Thus Acceptable Macronutrient Distribution Ranges (AMDRs) have been established for macronutrients as percentages of total energy intake. These are ranges of macronutrient intakes that are associated with reduced risk of chronic disease, while providing recommended intakes of other essential nutrients.

Because much of this evidence is based on clinical endpoints (e.g., coronary heart disease, diabetes, cancer, and obesity), which point to trends rather than distinct endpoints, and because there may be factors other than diet that may contribute to chronic disease, it is not possible to determine a defined level of intake at which chronic disease may be prevented or may develop. Therefore, an AMDR is not considered to be a Dietary Reference Intake (DRI) that provides a defined intake level. An AMDR is provided to give guidance in dietary planning by taking into account the trends related to decreased risk of disease identified in epidemiological and clinical studies.

AMDRs are expressed as percentages of total energy intake because their requirements, in a classical sense, are *not* independent of each other or of the total energy requirement of the individual. Each must be expressed in terms relative to the others. A key feature of each AMDR is that it has a lower and upper boundary, some determined mainly by the lowest or highest value judged to have an expected impact on health. Above or below these boundaries there is a potential for increasing the risk of chronic diseases shown to effect long-term health. The macronutrients and their role in health are discussed in Chapter 3, as well as in Chapters 5 through 11.

PARAMETERS FOR DIETARY REFERENCE INTAKES

Nutrient Intakes

Each type of Dietary Reference Intake (DRI) refers to the average daily nutrient intake of individuals over time. The amount consumed may vary substantially from day-to-day without ill effects in most cases. Moreover, unless otherwise stated, all values given for Estimated Average Requirements (EARs), Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), or Acceptable Macronutrient Distribution Ranges (AMDRs) represent the quantity of the nutrient or food component to be supplied by foods from diets similar to those consumed in Canada and the United States. Healthy subgroups of the population often have different requirements, so special attention has been given to the differences due to gender and age, and often separate reference intakes are estimated for specified subgroups.

For some nutrients (e.g., trace elements), a higher intake may be needed for healthy people if the degree of absorption of the nutrient is unusually low on a chronic basis (e.g., because of very high fiber intake). If the primary source of a nutrient is a supplement, a higher or lower percentage may be absorbed and so a smaller or greater intake may be required, or an adverse effect may be demonstrated at a lower level of

intake. When this is an issue, it is discussed for the specific nutrient in the section "Special Considerations."

The DRIs apply to the apparently healthy population, and while the RDAs and AIs are levels of intake recommended for individuals, meeting these levels would not necessarily be sufficient for individuals who are already malnourished. People with diseases that result in malabsorption syndrome or who are undergoing treatment such as hemo- or peritoneal dialysis may have increased requirements for some nutrients. Special guidance should be provided for those with greatly increased nutrient needs or for those with decreased needs such as energy due to disability or decreased mobility. Although the RDA or AI may serve as the basis for such guidance, qualified medical and nutrition personnel should make necessary adaptations for specific situations.

Life Stage Groups

The life stage groups described below were chosen while keeping in mind all the nutrients to be reviewed, not only those included in this report. Additional subdivisions within these groups may be added in later reports. If data are too sparse to distinguish differences in requirements by life stage or gender group, the analysis provided in establishing the DRI may be presented for a larger grouping.

Infancy

Infancy covers the period from birth through 12 months of age and is divided into two 6-month intervals. Except for energy, the first 6-month interval was not subdivided further because intake is relatively constant during this time. That is, as infants grow, they ingest more food; however, on a body-weight basis their intake remains nearly the same. During the second 6 months of life, growth velocity slows, and thus daily nutrient needs on a body-weight basis may be less than those during the first 6 months of life.

For protein, amino acids, carbohydrate, fat, and *n*-6 and *n*-3 polyunsaturated fatty acids, the average intake by full-term infants who are born to healthy, well-nourished mothers and exclusively fed human milk has been adopted as the primary basis for deriving the AI during the first 6 months of life. This is the model used for other nutrients as well. The value established is thus not an EAR. The extent to which intake of human milk may result in exceeding the actual requirements of the infant is not known, and ethics of human experimentation preclude testing the levels known to be potentially inadequate. Therefore, the AI, while determined from the average composition of an average volume of milk consumed by

this age group, is not an EAR in which only half of the group would be expected to have their needs met.

Using the infant fed human milk as a model is in keeping with the basis for estimating nutrient allowances of infants developed in the last revisions of the RDAs (NRC, 1989) and Recommended Nutrient Intakes (RNIs) (Health Canada, 1990). It also supports the recommendation that exclusive human-milk feeding is the preferred method of feeding for normal, full-term infants for the first 4 to 6 months of life. This recommendation has also been made by the Canadian Paediatric Society (Health Canada, 1990), the American Academy of Pediatrics (AAP, 1997), and in the Food and Nutrition Board report, *Nutrition During Lactation* (IOM, 1991).

In general, for this report, special consideration was not given to possible variations in physiological need during the first month after birth, or to the variations in intake of nutrients from human milk that result from differences in milk volume and nutrient concentration during early lactation. Specific DRIs to meet the needs of formula-fed infants are not proposed in this report. The previously published RDAs and RNIs for infants have led to much misinterpretation of the adequacy of human milk because of a lack of understanding about their derivation for young infants. Although they were based on human-milk composition and volume of intake, the previous RDA and RNI values allowed for lower bioavailability of nutrients from nonhuman milk. However, where warranted, information discussing specific changes in bioavailability or source of nutrients for use in developing formulations is included in the "Special Considerations" section of each chapter.

Ages 0 Through 6 Months. To determine the AI value for infants ages 0 through 6 months, the mean intake of a nutrient was calculated by multiplying the average concentration of the nutrient in human milk produced during the second through sixth month of lactation (derived from consensus values from several reported studies [Atkinson et al., 1995]) by the average volume of milk intake of 0.78 L/d as reported from studies of full-term infants by test weighing (Butte et al., 1984; Chandra, 1984; Hofvander et al., 1982; Neville et al., 1988). Because there is variation in both of these measures, the computed value represents the mean. It is assumed that infants will have adequate access to human milk and that they will consume increased volumes as needed to meet their requirements for maintenance and growth.

Ages 7 Through 12 Months. The reference body-weight method that has been used in previous DRI reports to extrapolate the AI for infants 0 through 6 months to an AI for older infants in the absence of direct data

on older infants (IOM, 1997) is not appropriate for dietary fats or carbohydrates. This is because the amount of energy required on a body-weight basis is significantly lower during the second 6 months of life, due largely to the slower rate of weight gain/kg of body weight. Therefore, the basis of the AI values derived for this age category for dietary fats and carbohydrates was the sum of the specific nutrient provided by 0.6 L/d of human milk, which is the average volume of milk reported from studies in this age category (Heinig et al., 1993), and that provided by the usual intake of complementary weaning foods consumed by infants in this age category (Specker et al., 1997). This approach is in keeping with the current recommendations of the Canadian Paediatric Society (Health Canada, 1990), the American Academy of Pediatrics (AAP, 1997), and *Nutrition During Lactation* (IOM, 1991) for continued feeding of human milk to infants through 9 to 12 months of age with appropriate introduction of solid foods.

Toddlers: Ages 1 Through 3 Years

Two points were primary in dividing early childhood into two groups. First, the greater velocity of growth in height during ages 1 through 3 years compared with ages 4 through 5 years provides a biological basis for dividing this period of life. Second, because children in the United States and Canada begin to enter the public school system starting at age 4 years, ending this life stage prior to age 4 years seemed appropriate so that food and nutrition policy planners have appropriate targets and cutoffs for use in program planning.

Data are sparse for indicators of nutrient adequacy on which to derive DRIs for these early years of life. In these cases, extrapolation using the methods described in Chapter 2 has been employed.

Early Childhood: Ages 4 Through 8 Years

Major biological changes in velocity of growth and changing endocrine status occur during ages 4 through 8 or 9 years (the latter depending on onset of puberty in each gender); therefore, the category of 4 through 8 years of age is appropriate. For many nutrients, a reasonable amount of data is available on nutrient intake and various criteria for adequacy (such as nutrient balance measured in children 5 through 7 years of age) that can be used as the basis for the EARs and AIs for this life stage group.

Puberty/Adolescence: Ages 9 Through 13 Years and 14 Through 18 Years

Because current data support younger ages for pubertal development, it was determined that the adolescent age group should begin at 9 years. The mean age of onset of breast development (Tanner Stage 2) for white girls in the United States is 10.0 ± 1.8 (standard deviation) years; this is a physical marker for the beginning of increased estrogen secretion (Herman-Giddens et al., 1997). In African-American girls, onset of breast development is earlier (mean $8.9 \text{ years} \pm 1.9$). The reason for the observed racial differences in the age at which girls enter puberty is unknown. The onset of the growth spurt in girls begins before the onset of breast development (Tanner, 1990). The age group of 9 through 13 years allows for this early growth spurt of girls.

For boys, the mean age of initiation of testicular development is 10.5 to 11 years, and their growth spurt begins two years later (Tanner, 1990). Thus, to begin the second age category at 14 years and to have different EARs and AIs for girls and boys for some nutrients at this age seems biologically appropriate. All children continue to grow to some extent until as late as age 20 years; therefore, having these two age categories span the period of 9 through 18 years of age seems justified.

Young Adulthood and Middle-Aged Adults: Ages 19 Through 30 Years and 31 Through 50 Years

The recognition of the possible value of higher nutrient intakes during early adulthood on achieving optimal genetic potential for peak bone mass was the reason for dividing adulthood into ages 19 through 30 years and 31 through 50 years. Moreover, mean energy expenditure decreases during this 30-year period, and needs for nutrients related to energy metabolism may also decrease. For some nutrients, the DRIs may be the same for the two age groups. However, for other nutrients, especially those related to energy metabolism, EARs (and RDAs) are likely to differ for these two age groups.

Adulthood and Older Adults: Ages 51 Through 70 Years and Over 70 Years

The age period of 51 through 70 years spans the active work years for most adults. After age 70, people of the same age increasingly display variability in physiological functioning and physical activity. A comparison of people over age 70 who are the same chronological age may demonstrate as much as a 15- to 20-year age-related difference in level of reserve

capacity and functioning. This is demonstrated by age-related declines in nutrient absorption and renal function. Because of the high variability in functional capacity of older adults, the EARs and AIs for this age group may reflect a greater variability in requirements for the older age categories. This variability may be most applicable to nutrients for which requirements are related to energy expenditure.

Pregnancy and Lactation

Recommendations for pregnancy and lactation may be subdivided because of the many physiological changes and changes in nutrient need that occur during these life stages. In setting EARs and AIs for these life stages, however, consideration is given to adaptations to increased nutrient demand, such as increased absorption and greater conservation of many nutrients. Moreover, nutrients may undergo net losses due to physiological mechanisms regardless of the nutrient intake. Thus, for some nutrients, there may not be a basis for EAR values that are different during these life stages than those for nonpregnant or nonlactating women of comparable age.

Reference Heights and Weights

Use of Reference Heights and Weights

Reference heights and weights are useful when more specificity about body size and nutrient requirements are needed than that provided by life stage categories. For example, while the EAR may be developed for the 4- to 8-year-old age group, a small 4-year-old child may be assumed to require less than the EAR for that age group, whereas a large 8-year-old may require more than the EAR. Based on the model for establishing RDAs, however, the RDA (and for that matter, an AI) should meet the needs of both.

In some cases, where data regarding nutrient requirements are reported on a body-weight basis, it is necessary to have reference heights and weights to transform the data for comparison purposes. Frequently, where data regarding adult requirements represent the only available data (e.g., on adverse effects of chronic high intakes for establishing Tolerable Upper Intake Levels [ULs]), extrapolating on the basis of body weight or size becomes a possible option to providing ULs for other age groups. Thus, for this and other reports, when data are not available, the EAR or UL for children or pregnant women may be established by extrapolation from adult values on the basis of body weight.

TABLE 1-1 New Reference Heights and Weights for Children and Adults in the United States

Sex	Age	Previous Median Body Mass Index ^a (kg/m ²)	New Median Body Mass Index ^b (kg/m ²)	New Median Reference Height, ^b cm (in)	New Reference Weight, ^c kg (lb)
Male, Female	2-6 mo	—	—	62 (24)	6 (13)
	7-12 mo	—	—	71 (28)	9 (20)
	1-3 y	—	—	86 (34)	12 (27)
	4-8 y	—	—	115 (45)	20 (44)
Male	9-13 y	15.8	15.3	144 (57)	36 (79)
	14-18 y	18.5	17.2	174 (68)	61 (134)
	19-30 y	21.3	20.5	177 (70)	70 (154)
	14-18 y	24.4	22.5	144 (57)	37 (81)
Female	9-13 y	18.3	17.4	163 (64)	54 (119)
	14-18 y	21.3	20.4	163 (64)	57 (126)
	19-30 y	22.8	21.5	163 (64)	57 (126)

^a Taken from male and female median body mass index and height-for-age data from the Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994; used in earlier DRI reports (IOM, 1997, 1998, 2000a, 2000b, 2001).

^b Taken from new data on male and female median body mass index and height-for-age data from the Centers for Disease Control and Prevention (CDC)/National Center for Health Statistics (NCHS) Growth Charts (Kuczmarski et al., 2000).

^c Calculated from CDC/NCHS Growth Charts (Kuczmarski et al., 2000); median body mass index and median height for ages 4 through 19 years.

New Reference Heights and Weights

As is described in Appendix B, the DRI framework is an iterative process that was undertaken in 1994. At that time, reference heights and weights used in the DRI reports for the U.S. and Canadian populations were developed based on data from the Third National Health and Nutrition Examination Survey on body mass index (BMI) for children and young adults (IOM, 1997). With the recent publication of new U.S.-based growth charts for infants and children and the introduction of BMI recommendations for adults (Kuczmarski et al., 2000), reference heights and weights for adults and children have been updated. Besides being more current, these new reference heights and weights are more representative of the U.S. population. Table 1-1 provides these updated values. Appendix B includes information about the reference values that were used in the earlier DRI reports.

SUMMARY

Dietary Reference Intakes (DRIs) is a generic term for a set of nutrient reference values that include the Estimated Average Requirement, Recommended Dietary Allowance, Adequate Intake, and Tolerable Upper Intake Level. In addition, to provide guidance on the appropriate macronutrient distribution thought to decrease risk of disease, including chronic disease, Acceptable Macronutrient Distribution Ranges are established for the macronutrients. These reference values have been developed for life stage and gender groups in a joint U.S. and Canadian activity.

This report—one volume in a series—covers the DRIs for the dietary macronutrients: carbohydrate, fiber, fat, cholesterol, protein, and amino acids. It also provides recommendations for physical activity and energy expenditure to maintain health and decrease risk of disease.

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